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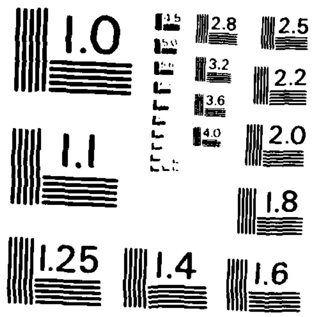

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Report DAAK10-8[illegible] 0003

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INDEPENDENT ASSESSMENT OF TRADE-OUT
DETERMINATION AND TRADE-OFF ANALYSES
FOR DIVISION SUPPORT WEAPON SYSTEM

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30 March 1983

FINAL REPORT FOR PERIOD
February 8, 1983-March 30, 1983

Prepared for:

Project Manager
Cannon Artillery Weapons Systems
Attn: DRCPM-CAWS
Dover, NJ 07801

Under Purchase Order Issued by
Department of the Army
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Attn: DRDAR-PRW-A[illegible], [illegible]
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The following is a summary of the conclusions drawn from review of DSWS TOD and TOA documentation coupled with discussions with representatives of the development and analytical communities. The major concern is predicted marginal survivability of the candidate DSWS. Suggested solution to the predicted marginal survivability problem is the use of applique armor for the chassis of the new DSWS. Additional suggestions to enhance the overall

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DSWS effectiveness include: an antihelicopter CHAFF round, a flechette round for defense against direct ground attack, improved MET data, replacement of copper rotating bands with plastic ones, and continued high priority emphasis on advanced propellants and remotely settable timed fuzes.

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CONTENTS

1. INTRODUCTION

This report provides the final results of the Purchase Order DAAK10-83-M-007 task performance requirements to conduct an independent assessment of Trade-Off Analysis and Trade-Off Determination for DSWS.

The purpose of this report is to provide comments resulting from the authors' independent assessment of DSWS draft TOA and TOD, plus the results of extensive conferences, meetings, and conversations with members of the developmental and analytical communities. These comments were formulated primarily by the principal analyst, Dr. Joseph Sperrazza, and reflect a perspective gained from many years experience in evaluating major weapons as Director of the U.S. Army Materiel System Analysis Agency (AMSAA).

The report is organized in the five following sections: an introduction which provides background information; a section that addresses the DSWS Survivability Conference, to include observations and follow-on actions; a section that reports a meeting with [illegible] on nuclear survivability/vulnerability; a section that provides independent comments on survivability made by the principal analyst regarding DSWS and related developments; and, a summary section.

2. DSWS SURVIVABILITY CONFERENCE

The office of the Project Manager, Cannon Artillery Weapon Systems (OPM, CAWS) hosted the DSWS Survivability Conference at ARRADCOM Dover, New Jersey, on January 11-12, 1983. This conference brought together both in-house and industry representatives that were interested in DSWS survivability. Detail presentations were made on actions ongoing to provide for a survivable DSWS. The stated objective was to identify "soft" areas where additional effort should be focused to better prepare for [illegible] I.

All participants were reminded of the four major deficiencies defined in the Mission Element Need document that provides the requirement for DSWS. Those stated deficiencies were: responsiveness, terminal effectiveness, RAM, and survivability. Development goals to address the deficiencies were divided into four broad areas: improved design, signature reduction, improved mobility, and minimum time to repair.

The user community presented a logical case for the need to develop a self-propelled howitzer (SPH) that can rapidly occupy a position, deliver effective munitions on the selected target in a short period of time, and quickly displace to a subsequent firing position. Concurrently, the SPH must be capable of being resupplied [illegible] vehicle (ARV) that provides protection for ammunition and crew from counterfire and [illegible] fragments. A prime consideration of the user is [illegible] in the forward area.

Many of the users' requirements can be met [illegible] of the [illegible] program, the adoption of [illegible] by associate programs, and state-of-the-art [illegible] to the M109.

First, the [illegible] in the Howitzer Extended Life Program (HELP), resulting from the [illegible] studies, will provide a positive step in increasing RAM, NBC protection, and survivability.

Noteworthy improvements, responding to the users' requirement for rapid emplacement/displacement, are automatic gun positioning to eliminate the need for a survey of each gun position, and remote control for the [illegible] lock and loader. [illegible] that survivability improvement [illegible] limited in this phase to fire suppression inside the vehicle. Second, the adaption of a tailored [illegible] package of SINCGARS, [illegible], and [illegible] equipments will provide the capability for [illegible] automatic processing of

technical fire control for the SPH. This, the incorporation of an automatic loader and gun laying device on the SPH drastically reduces the time required to [illegible] manually.

Assuming that these capabilities [illegible] to change in artillery tactics to reduce [illegible] to the enemy's concept of massive counterfires on located batteries. These tactics embody several new ideas. "Spread formation" of firing platoons allow for greater distances (not less than 300 [illegible] between firing units, thereby decreasing the enemy's ability for precision target location and reducing the overall battery exposure to counterfires. "Move on Incoming" allows for displacement of [illegible] of fire unit before enemy [illegible] effective while allowing other elements to continue firing.

The analysis done to date in support of these tactics do not consider offsetting factors such as: increased [illegible] requirements due to increased rate of fire and frequent movement; [illegible] for suitable terrain for subsequent firing positions; [illegible], changes in enemy tactics and equipment.

Analysis of these new tactics did not consider changes in countermeasures. For example, the enemy might deemphasize battery neutralization in favor of using [illegible] to force "move on incoming," and he might selectively [illegible] scatterable mines and/or infiltrate small unit ambushes with antiarmor weapons along likely displacement routes. The whole area of countermeasures should be examined to determine their impact on these new tactics.

The above discussion leads to one of the main issues presented to this conference; i.e., what is the threat? The presentation on the threat presented a lengthy catalog of possible enemy systems that have the capability to attack DSWS, but this was not [illegible] down to the most likely threat within the

context of the combined arms team operating against a postulated force. Of particular concern is disregard of future enemy munitions improvement ("smart" shells or controlled fragmentation) in analizing effects of counterfires. This type of analysis could lead to the wrong conclusions as to the vulnerability of propellants and the importance of the location for their storage, including compartmentalization and blow-out panels to protect the crew.

A presentation was made on the Statement of Work for the development/validation phase of DSWS. An [illegible] problem area became apparent in reviewing the draft SOW. [illegible] may be unaware of recently completed studies on related survivability issues. [illegible] AMSAA [illegible], [illegible], and [illegible] compartmentalization by blow-out panels, and also in maintenance and vulnerability studies regarding location of critical components and propellants.

The sum of these presentations provided interesting aspects of survivability when investigated by segments, and identified some technical factors that individually should help DSWS to survive. However, there seemed to be lacking any attempt to integrate all these factors into the overall system survivability within a reasonable scenario that gives credit to the enemy to improve both weapons and tactics during the time frame of interest.

A follow-on meeting was held to discuss some of the information presented at the DSWS Survivability Conference. At this meeting, the authors were requested to arrange conferences with AMSAA, FRL, BRL, and ARRADCOM to improve analytical data required to support the DSWS ASARC. Appendix A lists the conferences scheduled by location, subject, and attendees. The results of

these conferences will be reflected in the continuing analyses conducted by these agencies in support of [illegible].

3 NUCLEAR SURVIVABILITY/VULNERABILITY

A conference was scheduled at Harry Diamond Laboratories (HDL) Adelphi, Maryland to discuss an approach to assist [illegible] to address nuclear survivability/vulnerability [illegible]. This conference began with a definition of the basic survivability philosophy that equipment must survive if [illegible] crew members are predicted to survive and be expected to complete the assigned mission after a nuclear attack. Mission survivability requires identification and protection of all essential equipment including common and support equipment needed to [illegible] critical mission or function.

The nuclear threat was divided into two broad categories: the tactical threat (neutrons, gamma rays, blast, thermal, and EMP), and the high altitude burst threat (EMP). Emphasis during the remainder of the presentation centered on hardening against electromagnetic pulse because of the magnitude of vulnerable electronic components in DSWS and its common and equipment.

A review of the directives and regulations requiring specific nuclear survivability in materiel acquisition was conducted. In addition to the basic DODI's 5000.1, 5000.2, and 5000.3 a new DODI 3120.XX, "Acquisition of Nuclear Survivable and Enduring Systems", is currently being staffed and will probably be in effect at the time DSWS goes to DSARC review. Concurrently, AR70-60, "Army Nuclear Survivability", will provide the Army's similar requirements expanded to include consideration of force constitution and response to multiple burst. These instructions/regulations will require summaries of plans for nuclear survivability to be included in system concept papers (SCP), decision coordinating papers (DCP), and integrated program summaries (IPS).

To assist the project manager in defining the proper specifications for nuclear survivability, the following Data Item Descriptions have been published and should be included as requirements in statements of work presented to hardware contractors:

DI-R-1758 - NUCLEAR SURVIVABILITY PROGRAM PLAN

DI-R-1759 - NUCLEAR WEAPONS EFFECTS TESTS PLAN

DI-R-1760 - NUCLEAR WEAPONS EFFECTS TEST REPORT

DI-R-1761 - NUCLEAR SURVIVABILITY DESIGN PARAMETRIC REPORT

DI-R-17[illegible] - NUCLEAR SURVIVABILITY ASSURANCE PLAN

DI-R-176[illegible] - NUCLEAR SURVIVABILITY MAINTENANCE PLAN

One of the positive [illegible] assurance that the associated [illegible] (TACFIRE, [illegible] SINCGARS, PJH, PLRS) all have active programs for requirements to harden against EMP. A [illegible] is that the [illegible] to harden the M1 tank and to add NBC filters was done for less than 1% of hardware cost. The M1 was cited as a good example of a successful nuclear survivability program based on the fact that planning began early and nuclear survivability was a basic consideration in the design of critical components.

The importance of test and evaluation planning, including EMP evaluations of early prototypes and EMP simulator testing of the developed system, was emphasized. This type testing should be included in the DSWS master test plan.

HDL representative, Mr. John J.F. Corrigan, offers the assistance of his office and special expertise to advise DPCPM-CWW on all aspects of nuclear survivability. That offer

includes a briefing to OPM TAWS on this subject and preparation of an outline of the appropriate briefing for ASARC presentation.

4. SURVIVABILITY COMMENTS

[illegible]ment of the analysis [illegible] DSWS [illegible] and TOA [illegible] to a conclusion that the DSWSs under consideration cannot meet all critical [illegible]. In particular, neither the [illegible] the [illegible] with a ballistic [illegible] thickness [illegible] or equal [illegible] of aluminum can survive a [illegible] of the 1980's. The [illegible] will consist of a [illegible] of [illegible] weapons. [illegible] example, it is likely [illegible] will be able to produce [illegible], unguided [illegible], [illegible] controlled, [illegible] fragments. Recall that, [illegible] decade ago, Sweden developed a [illegible] round (called [illegible]) containing tungsten [illegible]. With [illegible] and [illegible] developed now one can obtain [illegible] forward spray of very effective fragments.

[illegible] and analyses should be integrated [illegible] useful survivability model. [illegible] important ingredient that must be [illegible] are detailed consequences of hits on the outer [illegible] from enemy ordnance (e.g., fragments, [illegible], [illegible], [illegible] rounds, HEAT rounds, [illegible], etc.). Each damage [illegible] must be established in detail [illegible] the residual [illegible] (speed and direction) of every fragment (including spall) and the damaging effects on each fragment, etc., on internal components. Then one can [illegible] relocate internal components and/or provide appropriate armor shielding. The vehicle must be tough enough to withstand some of the major threat weapons. It appears that none of the candidates [illegible] are tough enough.

To provide a continuing and timely service for modeling, it is suggested that the project hire the services of an outside

contractor. [illegible] should be made available to all inter-ested parties (governmental, [illegible] the office of [illegible] CAWS.

The idea of autonomous operations makes sense, but a serious vulnerability is apparent. [illegible] will make it difficult to provide local security, [illegible] [illegible].

[illegible] is suggested that [illegible]. In particular, [illegible] would require [illegible] of survivability, [illegible] [illegible].

Observations [illegible] the Yom [illegible] continuing case for the importance of [illegible], especially [illegible] tzers destroyed [illegible] with stowed [illegible] munity, especially [illegible] [illegible] ficer--and it [illegible].

With a [illegible] 100,0[illegible] lbs[illegible]), [illegible] land [illegible] achieved.

[illegible] will [illegible] FLOT and, at [illegible] ranges, deliver more precise fire with guided rounds. Moreover, it would be possible [illegible] special "guided" rounds such [illegible] improved [illegible] projectile,

which could be effective against enemy helicopters out to [illegible] 3 [illegible] 3 km, and a flechette round to be used against direct [illegible] attack.

Secondary Armament

The choice of a caliber 0.50 machine gun [illegible] is correct. But the present [illegible] is [illegible] of active choice, nor will the [illegible] self-[illegible] adequate reliability.

[illegible] ammunition should [illegible] light armored targets (like BMP's, [illegible]) [illegible] generally [illegible], are not at all competitive with tungsten [illegible]. In fact, [illegible] designed [illegible] Soviet [illegible] 100-[illegible] meters.

[illegible] they [illegible] potential [illegible] bullet [illegible] is perceived [illegible] community, [illegible] ball bullets [illegible] higher [illegible] upon person [illegible] penetration [illegible] MV^2 [illegible] now [illegible] value of MV^2 [illegible] above the knee of the [illegible] the [illegible] and [illegible]. Moreover, experiments with [illegible] and [illegible].

Against [illegible] bullets [illegible] and steel cored AP bullets [illegible]. It is obvious that tungsten cores [illegible].

penetration, p is

$$p \propto \rho^{2/3} m^{1/3} V$$

where ρ is penetrator density.

Thus it is recommended that the war reserve should be replaced with tungsten cored rounds. Present rounds should be used for training and for FMS (foreign military sales).

The use of a flechette round equipped with a remotely setable fuze (coupled with a knowledge of muzzle velocity and range to target) can provide good effects against helicopters and enemy ground troops.

Precision ammunitions

The studies to date ignore the [illegible] of [illegible] ing the accuracy of fire. [illegible] War II as to the reasons why [illegible] at 1000 yards in 7000 yards [illegible] still [illegible]. Those problems lay mainly in shell design tolerances.

- Poor exterior finish
- Exceptionally high dimensional tolerances
- Loose rotating bands
- Coppering/de-coppering effects

An associated program should be carried out to minimize these errors. In particular, serious consideration should be given to replace the present copper bands with a plastic one. Such replacements will virtually eliminate velocity trends within a tube and minimize tube-to-tube errors. Of importance is that one need not fire "warmer" rounds.

A further improvement of accuracy of fire is the knowledge of the velocity of every shell. Within today's state-of-the-art it is possible to develop a simple, nonrotating, velocimeter to do this. The proposed techniques are piezoids or strain gages mounted on the SPH muzzle to measure the velocity of each round. These data can be fed directly to a ballistic computer and thereby provide improved fire. The use of this muzzle velocimeter can [illegible] recalibration with [illegible] round. [illegible], by combining the velocity into the setting of remotely settable fuzes, one can achieve excellent precision for [illegible] and flechette rounds.

The problem of minimizing the effect of [illegible] in the field is a continuing one. A solution to this problem could be achieved by expansion of lot sizes [illegible] of propellant. Determination and elimination of the causes of large lot-to-lot variances [illegible] also be achieved.

The current Meteorological Data System (MDS) development should enhance field artillery accuracy, and, consequently, enhance the terminal effects of conventional munitions. Thus, with precise ammunition, velocimeters, remotely settable fuzes and accurate and timely MET messages, it is possible to deliver conventional ammo fire that could perform some missions now envisioned for terminally guided munitions.

Programs that could lead to the improvements just enumerated should be started now so the results are applicable to all howitzers.

Automatic Fire

Technical problems of developing and fielding an effective and reliable automatic loader would be ameliorated considerably with a larger and more survivable vehicle. That automatic fire

is needed is without question. During surge situations automation is akin to adding one howitzer to the work of two. The tough [illegible] would enjoy a much higher [illegible] availability during battle and [illegible] reduce the requirement of supplying a high maintenance [illegible].

A [illegible] of improved propellants suitable for automation [illegible] with high [illegible].

Transportability

[illegible]rational requirements [illegible] new DSWS, i.e., rate of fire, automation, increased range, and enhanced survivability [illegible] weight beyond the [illegible] the CH[illegible] [illegible]. Therefore [illegible] as a design goal, the [illegible] the new [illegible] envelope (weight, [illegible]).

7. [illegible]

[illegible]

The major concern is predicted marginal survivability [illegible] candidate DSWS. Threats [illegible] in the [illegible] analyses [illegible] address controlled fragmentation H.E. ammunition or scatterable mines. Both of these types of munitions are within the enemy's capability in the time frame of interest, and appear to be likely countermeasures [illegible] a DSWS using the proposed tactics (i.e. "spread formation" and "move on incoming").

A suggested solution to the predicted marginal survivability problem is the use of [illegible] armor for the chassis of the new DSWS.

(The extent of engineering required in the suggested modification has not been addressed.) This approach appears to correct the potential shortfalls in survivability including NBC protection. An alternative to this suggested solution would be the use of the M1 tank chassis. This alterntaive offers potential for: R&D cost reductions (i.e., no requirement to develop a new power plant, suspension, and hull); production cost savings as a result of larger procurement quantities; and, standardization of components.

Additional suggestions to enhance the overall DSWS effectiveness include: an antihelicopter STAFF round; a flechette round for defense against direct ground attack; improved MET data; replacement of copper rotating bands with plastic ones; and, continued high priority emphasis on advanced propellants and remotely settable timed fuzes.

APPENDIX A

Conferences [illegible] to [illegible] data required to support the DSWS ASARC review.

Location	Subject	Attendees
USARRADCOM Dover, NJ	Description of the problem. Provided copy of TOD.	J. Sperrazza, Consultant M. Fisette, CWW
[illegible] Alexandria, VA	Army Product Improvement Programs including the M109, 155mm SPH.	J. Sperrazza, Consultant G. [illegible] Roberts and staff
USARRADCOM Dover, NJ	Participation in DSWS Survivability Conference and follow-on meetings and discussions.	H. Shelton, [illegible] [illegible] Menke, [illegible] [illegible], CWW M. Fisette, CWW M. Della Terza, [illegible]
USARRADCOM Dover, NJ	[illegible] of survivability data and Analysis. Provided copy of TOA. Request for J. Sperrazza to visit BRL, [illegible], Md, and review support work for DSWS.	J. Sperrazza, Consultant H. Shelton, XM[illegible] M. Fisette, CWW M. Della Terza, CWW
BRL, APG, MD	Conference on improving methodology for predicting survivability of the M109 SPH.	J. Sperrazza, Consultant D. Kinsler, BLV-F W. Kokinakis, BLV-F
AMSAA, APG, MD	Conference on Survivability measures for M109. Protection of [illegible], by compartmentalization and blow-out panels.	J. Sperrazza, Consultant R. Bailey
BRL, APG, MD	Follow-on to previous conference with an [illegible] on how to improve M109 SPH survivability data.	J. Sperrazza, Consultant [illegible] Zeller, ASI W. Kokinakis, BLV-F

APPENDIX A (Con't)

Conferences arranged to improve analytical data required to support the DSWS ASARC review.

Location	Subject	Attendees
HDL Adelphi, MD	Nuclear vulnerability survivability data required for the DSWS program.	J. Sperrazza, Consultant H. Shelton, XMCO J. Corrigan, [illegible]
USARRDCOM Dover, NJ	Reviewed system analysis concern of DSWS: rate of fire, delivery precision, quick MET message, large lot size for propellants, elimination of copper rotation bands.	J. Sperrazza, Consultant J. Brooks, LCS-A S. [illegible]

APPENDIX B

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